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A SYSTEMS ANALYSIS OF POLITICS: A
MATHEMATICAL APPROACH

JOHN JAMES DITTRICK, JR.

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A SYSTEMS ANALYSIS OF POLITICS:

A MATHEMATICAL APPROACH

by

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Submitted in partial fulfillment
for the degree of

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ABSTRACT

Certain aspects of political functioning are investigated through the use of mathematical systems analysis techniques. Formal relationships are developed with respect to some of the elementary functions involved in politics. These relationships involve society and the political system in terms of demands, decisions and stress. Further, the concepts of communications and specialization are introduced as means of enhancing the ability of the political system to make satisfying decisions. The functioning of the system is analyzed in its steady state and a comparison is made with and without the introduction of lag time.

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1. Introduction.

An enterprise of thought which is still continuing today is to develop a theory of politics. The purpose behind such a theory is to better understand what politics is and what actually occurs within the sphere of politics. Several attempts have been made toward this end, notably the works of Karl W. Deutsch, Gabriel Almond & James Coleman and David Easton to mention only a few.¹

Such a theory of politics, as Karl Duetsch suggests, "should develop appropriate analytic concepts and models..."² In recent years political scientists have sought to interpret politics in terms of key analytic concepts, and several approaches have been made, ranging from area studies to systems analysis. For an idea of the quantity and variety of such attempts see, Roy C. Macrides and Bernaro E. Brown's "Comparative Politics - Notes and Readings".³ In this work the authors present the reader with several comparative studies which offer a comprehensive run of the field.

David Easton has argued that a general empirically oriented theory was the "most economical way in the long run to understand political life".⁴

¹Deutsch, K.W. The Nerves of Government. The Free Press of Glencoe, 1963. Almond, G.A. and Coleman, J.S. The Politics of the Developing Areas. Princeton University Press, 1960. Easton, D. A Systems Analysis of Political Life. John Wiley & Sons, 1965.

²Deutsch, op. cit., p. vii.

³Macridis, R.C. and Brown, B.E. Comparative Politics, Notes and Readings. The Dorsey Press, 1964.

⁴Easton, D. The analysis of Political Systems. Comparative Politics, ed. Macridis, R.C. and Brown, B.E. The Dorsey Press, 1964. p. 89.

In an attempt toward such a type of theory, David Easton turned toward viewing politics and political life in terms of systems analysis.⁵ In this thesis the author has attempted to extend the systems analysis type approach toward studying politics to include mathematical expressions denoting interrelationships between the systems involved. It is hoped that the basic mathematical approach followed in this thesis might offer greater insight into the complex concepts of political functioning.

Prior to expressing any mathematical relationships it will first be necessary to describe the overall system to be considered in this thesis and then to study more closely the various parts which comprise the system. Thus, this thesis will be divided into two main portions, the first being primarily concerned with the broad view of political life as a system, while the second will consist of a more detailed account of the components of such a system, paying particular attention to mathematical formulations.

2. Politics as a System.

David Easton defines a system as "any set of variables regardless of the degree of interrelationship among them." This definition was chosen to free the reader "from the need to agree about whether a political system is or is not really a system."⁶ The only question of importance, states Easton, is whether the set of variables selected as a system helps

⁵Easton, D. A Systems Analysis of Political Life. John Wiley & Sons, 1965.

⁶Ibid., p. 21.

us "to understand and explain some aspect of human behavior of concern to us." ⁷

For purposes of instruction, a political system will be defined here to be that system of interactions through which order is maintained in the society. In other words, the political system is assumed to behave as if it desires to maintain order in that society. One way in which the political system can help to maintain this order is by satisfying the people to whom it is responsible. That is, by effectively satisfying certain demands which the people make on the political system. Of course, the political system performs other functions, but the satisfaction of the people will be the primary role which is considered here. For a broader concept of the role of the political system see the introduction to Almond and Coleman's "The Politics of the Developing Areas." ⁸

Now once we speak of the political processes in political life as a system, certain consequences follow. As Easton Suggests: "The very idea of a system suggests that we can separate political life from the rest of social activity..." and examine it as though it were a "self contained entity" surrounded by the environment in which it operates. Easton divides this environment into two parts, namely what he calls "intra societal" and the "extra societal." ⁹ Generally the "intra societal" part consists of those systems in the same society as the political system, but not included

⁷Ibid., p. 21.

⁸Almond, op. cit., pp. 5-26.

⁹Easton, op. cit., pp. 21-22.

in the latter. In a society, the systems, including the political system, constitute a source of influences that have direct bearing on the condition under which the political system operates. The "extra societal" part consists of those systems that lie outside the society. This thesis will be restricted to the intra societal aspects—that is, the environment within which the political system must function, will, in this analysis, consist only of systems which are a part of the society. Further, the political system will be considered as a component of this society.

2.1 Political System.

It will be convenient to look upon the political system as having inputs and outputs. In order for this concept to have any meaning it is necessary that the political system have boundaries, in much the same sense as a physical system. This boundary may be considered as the points where other systems in the environment end and the political system begins. To illustrate, consider the situation where certain members of the society are muttering protests concerning the manner in which taxes are apportioned. Now these mutterings do not become a part of the political system until they are actually heard by members of the political system or until they are "witnessed", as would be the case if violence or riots were to result from such unrest. With this in mind we can now view the political system as it is shown in Figure I.

Since we have defined the political system to be separate from the rest of the social systems and since we have restricted our environment to consist only of intra societal systems, it will be convenient to simply refer

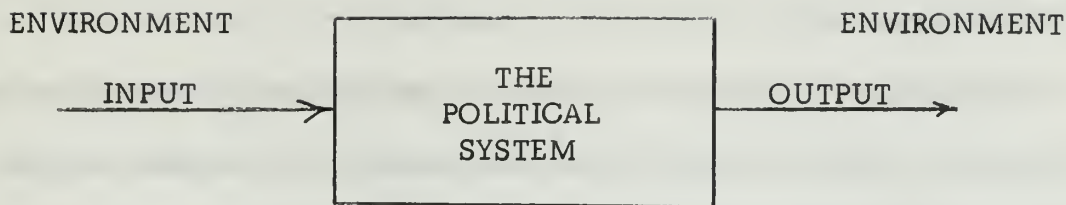


FIGURE 1

BASIC POLITICAL SYSTEM

to the environment as the society, where society includes all social systems except the political system. Thus, Figure 1 may be modified somewhat so as to appear as in Figure 2.

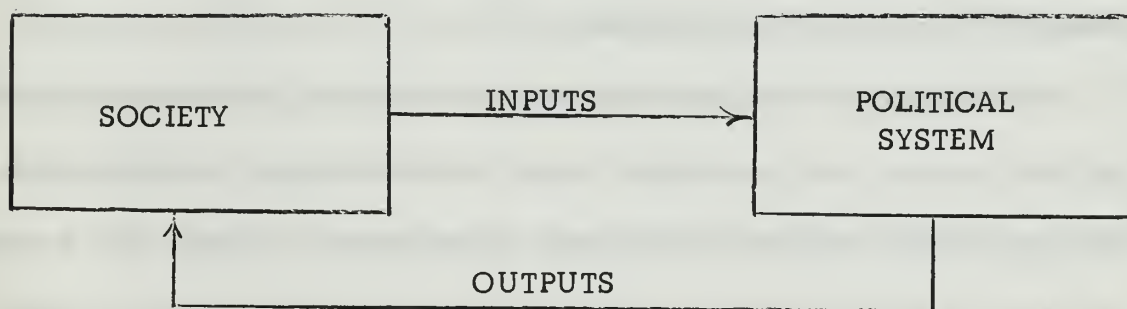


FIGURE 2

SOCIETY AND THE POLITICAL SYSTEM

The inputs are converted by the processes of the political system into outputs which, in turn, have consequences both for the political system and society. In order to understand the functioning of the political system it is necessary to identify these inputs and the factors which affect them, to trace the conversion process whereby inputs are converted to outputs within the system, and to relate these outputs with succeeding inputs into

the political system.

At this point it should be pointed out that this thesis will be concerned only with the "short run" view of the functioning of the political system. In other words, the analysis of major processes which promote social change will not be considered. In restricting the analysis to the "short run" the political system may be thought of in terms of classic mechanistic equilibrium, where the system receives disturbances from its environment. If such disturbances are small, the equilibrium will be restored through the action of the system, whereas if the disturbance is too large then general lapse of the system will result. Karl Deutsch treats this concept in more detail in "The Nerves of Government".¹⁰

From Figure 2 it is seen that whatever disturbances are to affect the political system must necessarily come from the society. In other words the inputs to the system contain these disturbances. Further, it is assumed here that all such disturbances tend to hinder the viability of the system. David Easton considers disturbances to also include those disturbances which are favorable with respect to the persistence of the system.¹¹ In this thesis, it will be convenient to view any favorable disturbances not as something which the system responds to, but rather as something which increases its capability to effectively handle the unfavorable influences. This allows us to stay within the mechanistic equilibrium concept, for if

¹⁰Deutsch, op. cit., pp. 182-200.

¹¹Easton, op. cit., p. 22.

we allowed favorable disturbances, the system would not react to such disturbances so as to return to its initial state. Rather it would seek some higher state.

Now among the inputs to the political system it is postulated that there are two basic kinds: demands and stress. The outputs will consist primarily of decisions made by the political system in response to the inputs it observes. The only decisions to be considered will be those brought about by demands and stress. Of course, other type decisions are possible. As Deutsch points out, the political system, in addition to responding to specific demands, may also assume a generalized leadership role.¹² That is, the political system assumes responsibility far beyond a particular decision. This leads into a long run analysis which, as mentioned earlier, will not be pursued in this thesis.

The concepts of demands, decisions and stress will now be considered in somewhat greater detail.

2.1.1 Demands.

The author agrees with Easton's assertion that the reason a political system comes into a society is that demands are being made by persons or groups which cannot all be satisfied. In all societies it can be assumed that scarcity prevails with regard to those things which are considered to be of value. In pursuing these valued items, disagreement between persons resulting from conflicting means of attaining such items can sometimes be

¹²Deutsch, op. cit., p. 118.

resolved by the persons involved. In other cases, however, the affair must be settled authoritatively through some sort of organized procedures. When a specific disagreement requires these organized procedures for settlement we say that from this disagreement demands are placed on the political system.

These demands may come from several different sources. For instance there are demands concerning religion, demands concerning ecology and demands concerning the economy. This is not an exhaustive list, but it does offer some insight into the complexity of the problem of how and why demands are generated. The specific sources of each demand represent quite an extensive list and it will not be attempted to define each of these sources. It will be assumed, however, that all demands emanate from the society and that none actually are born within the political system.

As implied earlier, a demand must be "heard" or "witnessed" by the political system if any effective action is to be taken. That is, there must be some means whereby demands are effectively carried through the boundaries of the political system. The method by which demands are introduced into the political system is dependent upon several factors. Perhaps the most important system affecting a demand's successful penetration of the political system's boundary is that of communications. The importance of communications has been given great support by Deutsch¹³ and Lucean Pye who devoted an entire book toward analyzing political development in terms

¹³Ibid. pp. 145-162.

of communications.¹⁴ As Pye points out in his introduction, there is a "peculiarly intimate relationship between the political process and the communications process."¹⁵ The communication process of course plays an equally important role for decisions penetrating the boundary of society. In the initial formulation, the communications system will be assumed to be ideal - that is, all demands emanating from society do indeed penetrate the boundary of the political system, while all decisions issued by the political system effectively "reach" the society. Later, this assumption will be altered to allow for a communications system which is something less than ideal.

The importance of demands as an input to the political system cannot be emphasized enough. In this thesis, it is this input which the system requires in order to operate. The other input, stress, will be discussed after we consider the output of the political system, decisions.
WHERE ARE ALTERNATIVES IN THIS SYSTEM?

2.1.2 Decisions.

Almond and Coleman refer to the output functions of a political system to be "rule making", "rule application", and "rule adjudication".¹⁶ Without going into the specific meanings of each of these functions it suffices to say that they all represent some sort of decision. As implied in the discussion thus far, the type of decision is primarily dependent upon the type

¹⁴Pye, L.W. Politics, Personality, and Nation Building. Yale University Press, 1962

¹⁵Ibid. p. 6.

¹⁶Almond, op. cit., pp. 52-58.

of demand which it is in reference to. For instance, a decision concerning education may involve making a rule, applying this rule through some means and stating that not adhering to such a rule is in fact, illegal.

Earlier we assumed that the political system behaved as if it desired to maintain order in the society. One of the major ways of preventing disorder is to keep everyone in the society satisfied. Thus, the political system can help to maintain order by providing decisions that tend to satisfy the demands of the members of the society. It is the responsibility of the political system to match the outputs of decisions with inputs of demand. Carl Friedrich discusses order at great length in "Man and His Government" and he even considers the benefits which may be realized by purposely creating disorder.¹⁷ This aspect of the problem, however, will not be considered here. Two factors which aid in giving better quality and/or satisfaction to decisions will be considered in this thesis. One, is the quality of the communications available and the other is the amount of differentiation within the political system. The first idea is discussed above. The second concept is now presented.

Several authors¹⁸ refer to the concept of differentiation within the

¹⁷Friedrich, C.J. Man and His Government. McGraw-Hill, 1963. pp. 335-350.

¹⁸See especially: LaPalombara, J. Bureaucracy and Political Development: Notes, Queries and Dilemmas. Bureaucracy and Political Development, ed. LaPalombara, J. Princeton University Press, 1963. pp. 34-61. Diesing, P. Reason in Society. University of Illinois Press, 1962. pp. 169-190. Also Friedrich and Almond discuss the concept in their books.

political system. Paul Diesing claims that any decision making structure must have as one of its characteristics, differentiation, if it is to exist at all.¹⁹ This decision making structure, or political system as used here, must "make possible the presentation of a plurality of parts, values, norms and action alternatives".²⁰ He claims that at least two of each one of these is necessary, otherwise no decision would be possible because there would be no alternatives. This is known as differentiation. As differentiation is used to a greater degree, the decisions emanating from the political system will be improved. As used in this thesis, differentiation is directly related with complexity. Complexity refers to the number of different offices and functions within the political system. It is posulated that as complexity increases, the presentation of more plurality of facts, values, norms and action alternatives, and hence higher differentiation, will follow. One may also view differentiation of offices as a special instance of the universal law of division of labor as developed by sociology and economics.²¹

As an example of how complexity would be of benefit in yielding a more satisfying decision consider a demand concerning farm price supports. Now for a decision concerning farm price supports to have any value it will be necessary to consider a wide variety of factors; facts about costs, production, voting patterns, etc. Omission of any specific factor could lead to a poor decision yielding results which had heretofore been unanticipated.

¹⁹Diesing, op. cit., pp. 177-190.

²⁰Ibid. p. 177.

²¹Friedrich. op. cit., p. 470.

For decisions to be effective they must be followed by the members of the society for whom they are intended. This brings up the question of the authority of the political system to impose its decisions upon society. Easton suggests that authority is a special power relationship based on the expectation that if the political system makes a decision the members of society will adapt this decision as "the premise" of their own behavior.²² Carl Friedrich considers the power inherent in authority is likely to be a consensual power.²³ In the political system described in this analysis it is assumed that the members of the political system have a right to command and the other members of society a duty to obey. There do exist, however, other sources of power to supplement this kind of power which is "understood". We will refer to this supplementing power as enforcement. That a political system must resort to enforcement is an indication that the members of society are less than satisfied with the decisions made by the political system.

2.1.3 Stress.

The final concept to be considered in this analysis is that of stress. To better understand this concept, recall that the primary function of the political system, as defined in this thesis, is to maintain order within society. This is done by making satisfactory decisions with respect to the demands placed on the system. When the ability of the political system to perform this function decreases we say that the system is being stressed.

²²Easton, op. cit., p. 07.

²³Friedrich, op. cit., pp. 224-226.

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Ideally the political system seeks a situation in which there is no stress. cloudy
THANKS

Stress results from the disturbances placed on the system, which in the model considered here, are the demands emanating from members outside the political system. If the demands are satisfactorily answered through proper decisions then the political system may be viewed as having successfully responded to the disturbances and has returned to the equilibrium position of zero stress. If, on the other hand, the political system did not respond so successfully to disturbances placed on it, then it would be under stress.

If the amount of stress reached a point where the political system could no longer maintain order through its decision making capability, it would collapse for want of a system which could perform this function. This level of stress will be referred to as the critical level.

Up to this point politics has been considered as a system and the methodology of systems analytic techniques have been employed to facilitate some of the basic interrelationships of the political system with its environment. The functional relationships existing between the political system and its environment have been expressed in general terms in order to offer the reader some insight into the factors which are considered relevant. Having laid the ground work, it will now be attempted to express these interrelationships in mathematical terms in hopes of bringing the general ideas into sharper focus.

3. Mathematical Analysis.

For expository reasons, the model will develop in stages whereby concepts are introduced separately. The first such concept will be that of stress as it is related to demands and decisions. Once this relationship has been defined, the other concepts discussed in section 2 will be added.

In order to better understand the analysis to follow it will be convenient to make use of flow diagrams. The first such diagram is depicted in Figure 3, which is an adjustment of Figure 2. If we consider society and

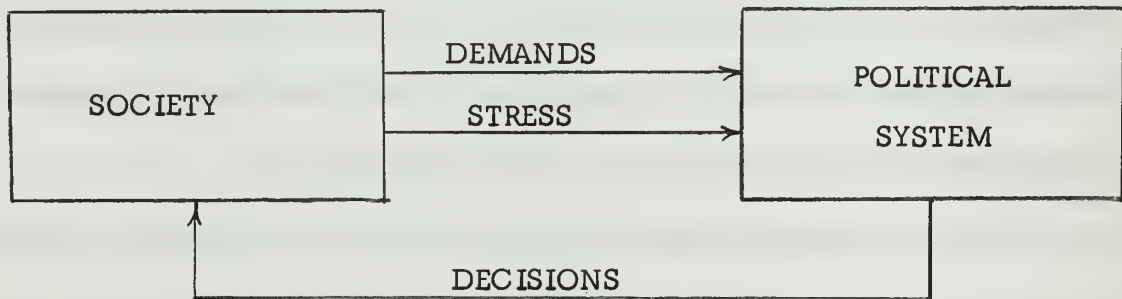


FIGURE 3

SOCIETY AND THE POLITICAL SYSTEM (MODIFIED)

the political system as two distinct "black boxes", we may regard these "black boxes" as devices for converting inputs into certain outputs. That is, demands are transformed into decisions, which are fed back to society where they are somehow transformed into stress. This idea of "feed back" will be followed throughout the analysis.

3.1 Stress.

In order to express stress as some function of demands and decisions, volumes of demands and decisions will be considered. Deutsch and Easton both write of the actual measuring of these factors.²⁴ Now, when speaking of volume of demands it will be convenient to refer to demands by type. For example, fifty persons may each place a demand on the government, but if all these demands are of the same type then the political system observes a volume of only one demand. A spokesman for a group of persons actually aggregates several similar demands and takes it through the boundary of the political system as one demand. If we consider stress to be proportional to the difference between the number of demands and satisfactory decisions concerning these demands, the discussion can be presented symbolically in the following manner:

S_t - total stress due to unsatisfied demands at time t

D_{t-1} - volume of demands by type the political system observes during a unit time interval

$D_{s(t-1)}$ - volume of decisions which satisfied demands during unit time interval.

S_{t-1} - stress which existed at the beginning of the time interval in question.

B - proportionality constant-stress/unsatisfied demands
where the units of stress are arbitrary.

$$\text{Then } S_t = B(D_{t-1} - D_{s(t-1)}) + S_{t-1} \quad (1)$$

²⁴Deutsch, op. cit., pp 125-126 and Easton, op. cit., pp. 61-64.

The proportionality constant, B , is assumed to be positive since it is postulated that stress increases as the difference between demands and decisions increase.

Stress is expressed in terms of a difference equation to facilitate expressing the argument verbally. To manipulate this and other equations to follow, however, it will be convenient to do so in terms of continuous differential equations. This technique should offer no loss of generality in the analysis. Thus, re-arranging equation (1) as:

$$S_t - S_{t-1} = B(D_{t-1} - D_{s(t-1)}) \quad (2)$$

the analogous differential equation may be expressed as:

$$\frac{Ds}{Dt} = B(D - D_s) \quad (3)$$

For reasons of analysis it is assumed that demands and satisfying decisions vary sinusoidally with time. Further, it is postulated that there exists a lag between the time when demands are first introduced into political system and the political systems converts such demands into satisfying decisions. This time lag will be denoted as τ and will be assumed to be fixed. For simplicity, the frequency with which demands enter the political system will be assumed equal to the frequency with which decisions are issued from the political system. Thus:

$$D = D_1 \sin W t \quad (4)$$

where D_1 = maximum number of demands entering the political system during some time period T . Let

$$D_s = D_{s1} \sin W (t - \tau) \quad (5)$$

where D_{s1} is the maximum number of satisfying decisions coming from the political system.

$$\frac{Ds}{Dt} = B (D_1 \sin Wt - D_{s1} \sin W(t - \tau)) \quad (6)$$

To solve for S, we integrate both sides of equation (7) yielding

$$S(t) = -\frac{BD_1}{W} \cos Wt + \frac{BD_{s1}}{W} \cos W(t - \tau) + C \quad (7)$$

where C is the constant of integration. For convenience, let stress, at time $T = 0$ be

$$S(0) = -\frac{BD_1}{W} + \frac{BD_{s1}}{W} \cos W\tau \quad (8)$$

which yields $C = 0$

Thus

$$S(t) = -\frac{BD_1}{W} \cos Wt + \frac{BD_{s1}}{W} \cos W(t - \tau) \quad (9)$$

Figure 4 is a plot of stress as a function of time. Superimposed on this plot are demands and decisions plotted as a function of time. The maximum number of satisfying decisions, D_{s1} was chosen to be less than the maximum number of demands D.

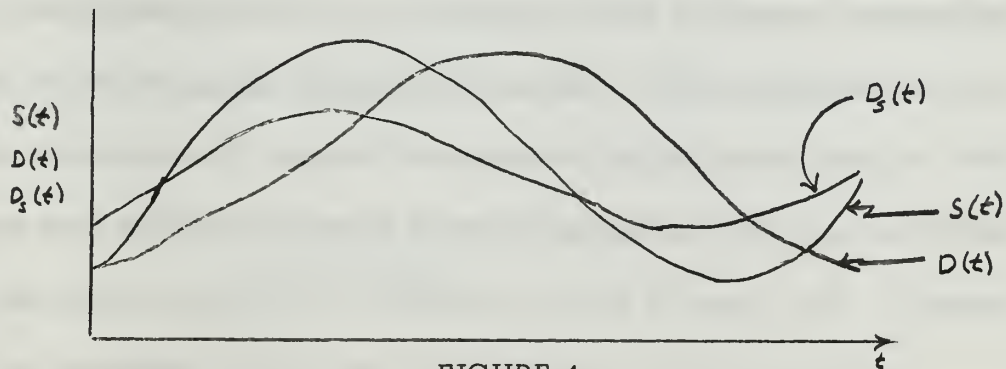


FIGURE 4

PLOT OF STRESS, DEMANDS AND DECISIONS

Referring to figure 4 we see that the rate of stress increases when demands exceed decisions and decreases when the opposite is true. For some time period it is quite possible that satisfying decisions would exceed demands. This is best illustrated through an example. If in time period 1 five demands were placed on the political system and during that time period only two satisfying decisions were made, the stress rate during that time period would be increasing. Now consider the next time period where only two demands were made. It is conceivable that during this time period the political system might make three satisfying decisions, one with respect to the previous time period and two with respect to the second time period. In this case decisions would exceed demands and the rate of stress would decrease. The time period is chosen arbitrarily as one unit where, for example, this unit could be a day, a week, or a month.

A more realistic approach toward the problem is to weight the demands according to the number of persons making that type of demand. For instance if one hundred persons voiced a demand for type A and only twenty were behind the demand type B, it is postulated that the political system would suffer more stress if it failed to satisfy type A than it would have had it failed to satisfy type B. That is, the political system would be "punished" more for ignoring or for failing to satisfy type A. It is assumed here that each individual can only express one type of demand during the time interval in question. This frees us from the problem of overlapping demands.

To account for this weighting one method is to consider the total number of demands to be equal to the total number of persons voicing these

demands. That is, if one hundred persons make a demand of type A, then this will be considered as one hundred demands of type A. Similarly, a satisfying decision would be one which satisfied one person. To illustrate, assume four demands were made during some time period, and that each of these four represented a different type. Let the number of persons making each demand be denoted in Table I

TABLE I	
Type Demand	Number of persons making this demand
1	50
2	80
3	100
4	60

The total volume of demands would be the sum of the right hand column, which, in this case, is 290. Now assume the political system made decisions which satisfied demand types 1 and 3 only. In this case the total number of satisfying decisions would be 150. The rate of stress would be proportional to the difference, 290 - 150, or 140. If the political system had satisfied types 1 and 4 instead, the difference would have been 180 which represents a higher rate of stress. Generalizing, let,

P_i = number of persons asking i th type of demand

x_i = (1 if i th demand satisfied) (0, otherwise)

Then

$$\bar{D} = \sum_{i=1}^D P_i x_i \quad (10)$$

where \bar{D} is the total number of different type demands and \bar{D} is the total number of individual demands, where individual demands are defined above. Let \bar{D}_s be the total number of satisfying decisions as defined earlier. Then

$$\bar{D}_s = \sum_{i=1}^D \alpha_i P_i \quad (11)$$

The rate of stress weighted due to the above argument can now be expressed as

$$\frac{D_s}{D_t} = B (\bar{D} - \bar{D}_s) \quad (12)$$

For simplicity, the remaining portion of this thesis will consider stress only as a function of demands and decisions by type.

The purpose of this section was to show how demands may be a contributing factor to the stress acting on a political system. For any unit time interval, it was shown that the rate of stress was proportional to the difference between demands and satisfying decisions. From this argument it is seen that any means of increasing satisfying decisions relative to demands would be advantageous to the political system. Some of the factors which affect satisfying decisions will now be studied in more detail. In analyzing these methods of increasing effective decisions, a probabilistic approach will be followed whereby the number of satisfying decisions emanating from the political system over some unit time interval will be expressed in terms of expected numbers of satisfying decisions. The two concepts to be considered are communications and complexity.

3.2 Communications.

As mentioned in section 3.1 the communications system is directly responsible for the passing of information through the boundaries of society and the political system. Up to this point we have assumed perfect communication - this is, all demands have reached the political system and all decisions have reached the society. Furthermore, such information was assumed to have passed the boundaries undistorted. An analytical method is now proposed by which the effect of communication may be taken into account. To better understand the system it will be helpful to refer to Figure 5 in which the communications system has been incorporated in the basic flow diagram.

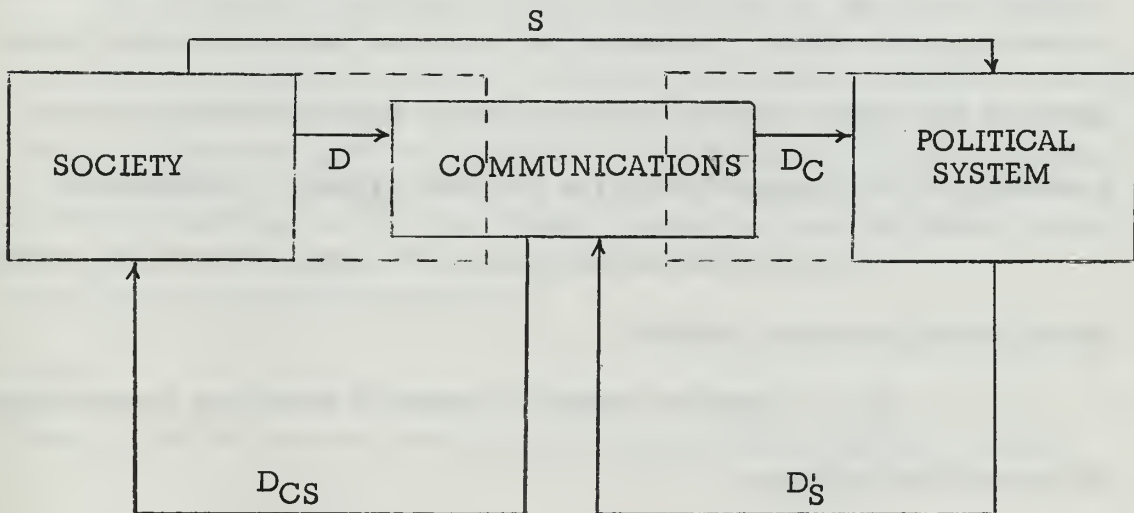


FIGURE 5

SOCIETY AND THE POLITICAL SYSTEM (MODIFIED)
INCLUDING COMMUNICATIONS

Referring to Figure 5, demands and decisions pass through a "black

box" called communications. Within the communications system demands and decisions are converted to communicated demands and decisions respectively. The dashed lines indicate that the communications system is actually a part of the boundaries of society and of the political system. Now suppose it is possible to determine the probability that a demand is successfully communicated to the political system, and that it is further possible to determine the probability that a decision is successfully communicated to the people. If one accepts this, it is then possible to talk of the expected number of satisfying decisions with respect to the demands generated. Using the expected number of satisfying decisions it is possible to gain some insight into how the stress rate might behave with respect to communications ability. It should be mentioned here that society is not aware of the loss of certain demands through communications and thus assumes that all demands reach the political system. Symbolically:

D = total number of demands by type generated by society during some given time interval.

D_C = expected number of demands which are communicated to the political system.

D'_S = expected number of satisfying decisions made by political system (these decisions have not yet been communicated).

D_{CS} = expected number of satisfying decisions which are communicated to the people.

P_C = probability that a demand is communicated to the political system.

P'_C = probability that a satisfying decision is communicated to the people.

P_S = probability that a decision concerning any demand will be satisfying.

Then

$$D_C = P_C D \quad (13)$$

$$D_{CS} = P'_C D'_S \quad (14)$$

To see the possible effects of communications on the rate of stress substitute equation (14) for D in equation (3) yielding

$$\frac{D_S}{D_t} = B (D - D_{CS}) \quad (15)$$

To illustrate the effects of communications on the rate of stress consider the following example. Suppose that within a specific time frame society voices six types of demands. Assume that all demands which had been made previous to the time frame in question were satisfied so that there are no demands carried over.

Thus $D = 6$

First, it will be assumed that perfect communication exists - that is

$$P_C = P'_C = 1$$

Then

$$D_{CS} = D = 6$$

Now suppose that the probability that decision will satisfy the demand is .8-then

$$D'_S = P_S D_C = 4.8$$

and since, perfect communications is assumed, it is seen that

$$D_{CS} = D'_S = 4.8$$

Based on this expected number of satisfying decisions which are communicated to the people, the stress rate would be expected to increase by an amount proportional to $D - D_{CS} = 1.2$. Now this stress rate will be compared with that resulting from imperfect communications.

Suppose the probability that a demand is communicated to the political system is .6. Then

$$D_C = P_C D = 3.6$$

and

$$D'_S = P_S D_C = 2.9$$

Assuming $P'_C = .8$

$$D_{CS} = P'_C D'_S = .8 (2.9) = 2.3$$

From this it is seen that the stress rate is now proportional to $D - D_{CS} = 6 - 2.3 = 3.7$. This is more than three times as much as that for perfect communications! Communications, then, plays an important role in controlling the rate of stress.

3.3 Complexity.

The second factor affecting satisfying decisions to be considered is that of complexity. As mentioned in 3.1, complexity is related to how the decision making processes are sub-divided within the political system.

Eisenstadt states that the "variety of political demands... which the (polit-

ical) system can absorb increases"²⁵ the more a political system is differentiated. Based on this assertion, it is postulated that the more differentiation or complexity there is within the political system the more capability that system will have in making satisfying decisions. For purposes of analysis complexity will be defined in terms of the number of sections within the political system. These sections may consist of one individual or several. The actual physical make-up of these sections is not of importance here. Further, each section is assumed to "specialize" or to be an "authority" on certain types of decisions. For example, a transportation system is considered to specialize in transportation problems, the education section with education decisions, and so on. Since these sections do specialize in specific decisions, it is postulated that if a certain type of demand is processed through a section which specialized in that type of demand, the resulting decision has a far greater chance of satisfying those who initiated the demand than a decision which would have resulted from other sections. It is assumed that when a demand of a certain type enters the political system it is assigned to the section which specializes in that type of demand. If no such section exists, it is assumed that the demand is then directed to a general section where it is processed with a lesser chance of being satisfied. This idea is illustrated in Figure 6.

²⁵Eisenstadt, S. N. Bureaucracy and Political Development. Bureaucracy and Political Development, ed. LaPalombara. Princeton University Press, 1963. p. 97.

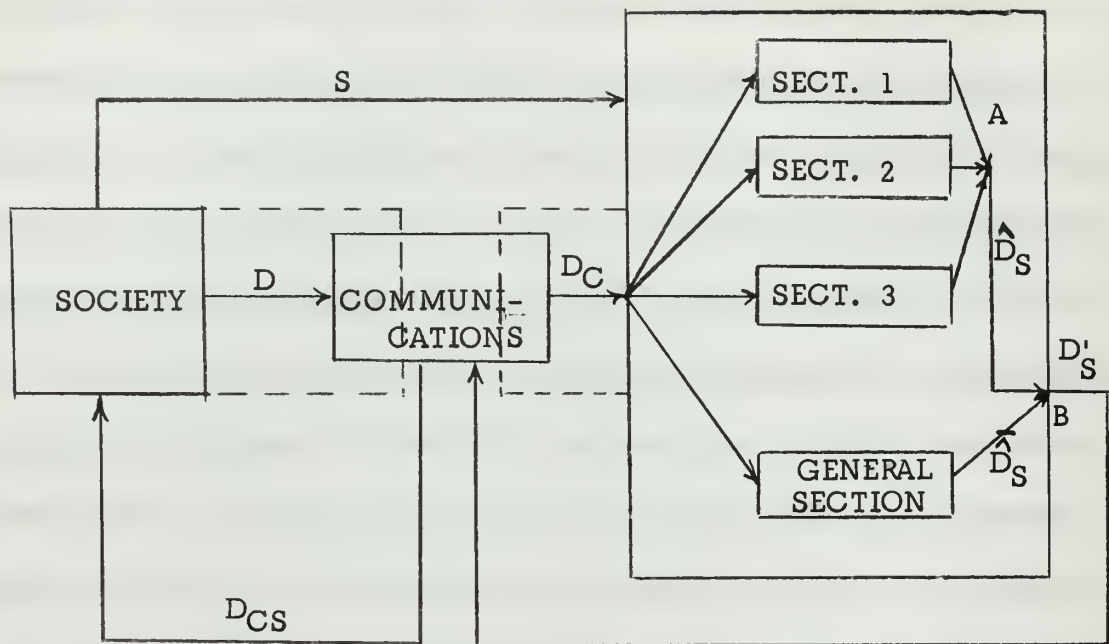


FIGURE 6

SOCIETY AND THE POLITICAL SYSTEM (MODIFIED) INCLUDING COMMUNICATIONS AND COMPLEXITY

For illustrative reasons, the communicated demands have been divided into four components. The first three demands are assigned to their respective sections while all "other" demands are assigned to the general section. Within each section the particular demand or demands are processed into decisions. At point A the decisions coming from the specialized sections are summed and assigned an overall probability of satisfaction. This sum yields an expected number of satisfying decisions coming from specialized sections represented by \hat{D}_S . Within the general section all decisions are also summed and assigned an overall probability of satisfaction which gives an expected number of satisfying decisions resulting from non specialized

sources. This is represented by \bar{D}_S . This analysis will now be presented symbolically.

Let C_m = number of sections into which political system is divided.

S_j = section specialized in j th type of demand.

D_{ci} = communicated demand of i th type.

D_c = total number of communicated demands by type.

\hat{D}_S = total number of decisions coming from specialized sections.

\hat{P} = probability that decisions coming from specialized sections will be satisfying.

\bar{P} = probability that decisions coming from non-specialized sections will be satisfying.

\hat{D}'_S = expected number of satisfying decisions coming from specialized sources.

\bar{D}_S = expected number of satisfying decisions coming from non-specialized sources.

D'_S = expected number of satisfying decisions coming from the political system.

Now D_S can be determined from the following relationship:

$$\hat{D}_S = \sum_{j=1}^{C_m} \sum_{i=1}^{D_c} S_j D_i$$

where $S_j D_i = \begin{cases} 1 & \text{if } i=j - \text{that is, if there exists a section which} \\ & \text{specializes in type } i \text{ demands} \\ 0, & \text{otherwise} \end{cases}$

From Figure 6 it is seen that

$$\bar{\hat{D}}_s = D_c - \hat{D}_s \quad (17)$$

Then

$$\hat{D}'_s = \hat{P} \hat{D}_s \quad (18)$$

$$\bar{\hat{D}}'_s = \bar{\hat{P}} \bar{\hat{D}}_s \quad (19)$$

and $D'_s = \hat{D}'_s + \bar{\hat{D}}'_s \quad (20)$

To clarify some of these points consider the following example.

Suppose five types of demands are successfully communicated to the political system. Suppose the system has sections which specialize in only three types of these demands. Let these sections be numbered 1, 2 and 3 respectively, and let the type demands corresponding to these sections be numbered in the same manner. For instance, if the sections specialized in health, education and transportation they could be assigned numbers as follows.

Section Type	Number
health	1
education	2
transportation	3

If the demands were concerned with labor, health, voting rights, education and transportation they would be assigned the following numbers

Demand Type	Number
labor	5
health	1

voting rights	4
education	2
transportation	3

From this information it is seen that

$$\hat{D}_s = S_1 D_1 + S_2 D_2 + S_3 D_3 = 3$$

and

$$\bar{D}_s = D_c - \hat{D}_s = 2$$

Now assume that the probability that decisions coming from specialized sections will be satisfactory is .8, while the probability concerning decisions coming from non-specialized sections is .4. This yields

$$\hat{D}'_s = \hat{P} \hat{D}_s = (.8)(3) = 2.4$$

and

$$\bar{\hat{D}}'_s = \hat{P} \bar{\hat{D}}_s = (.4)(2) = .8$$

and

$$D'_s = \hat{D}'_s + \bar{\hat{D}}'_s = 2.4 + .8 = 3.2$$

Thus from an input of 5 demands, 3.2 of these can be expected to be satisfying if perfect communication is assumed. If all 5 demands were processed by the non-specialized sources only $(.4)(5) = 2$ satisfying decisions could be expected. This analysis offers some idea of how complexity aids the political system in its attempt to issue satisfying decisions.

3.4 External Forces.

In this part of the thesis the concepts described in the previous sections will be incorporated to form a more general picture of the functioning

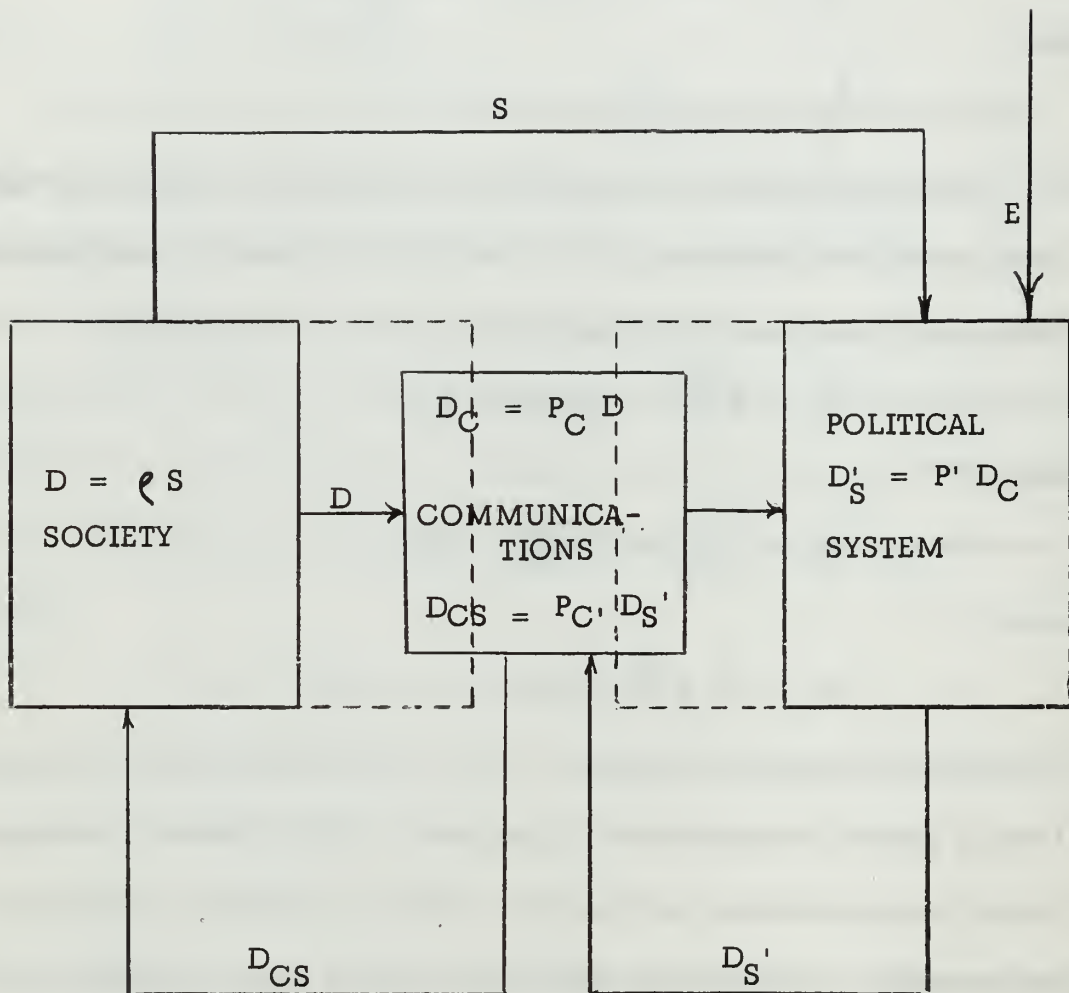


FIGURE 7

SOCIETY AND THE POLITICAL SYSTEM (MODIFIED) WITH
THE INTRODUCTION OF EXTERNAL FORCES

of the political system. Further, it is now postulated that forces external to society and the political system are free to act upon the political system. Such external forces might include, for example, international crises, flood, famine, or war. The affect of these external forces on the ability of the political system to issue satisfying decisions will be analyzed. Figure 7 is the flow diagram which will be followed in the analysis. For simplicity, the complexity portion of the political system is not shown in the diagram.

It is now postulated that the level of demands which the society issues is directly proportional to the level of stress that exists. That is, the more stress an individual feels the more demands he will make in order to attempt to alleviate this stress. Thus

$$D(t) = \rho S(t) \quad \rho > 0 \quad (20)$$

from which it follows that

$$\frac{dD(t)}{dt} = \rho \frac{dS(t)}{dt} \quad (21)$$

and

$$\frac{dD(t)}{dt} = \rho B [D(t) - D_{CS}(t)] \quad (22)$$

and, rewriting,

$$\frac{dD(t)}{dt} = \rho B [D(t) - BD_{CS}(t)] \quad (23)$$

For simplicity it is assumed that at time $t = 0$, no demands or decisions are present in the system. That is $D(0) = D_{CS}(0) = 0$. Now, using laplace transforms, it is seen that

$$SD(s) - \rho BD(s) = - \rho BD_{CS}(s) \quad (24)$$

from which

$$D(s) = \frac{-\ell^B D_{CS}(s)}{s + [-\ell^B]} \quad (25)$$

Referring to section 3.2, it is seen that communicated satisfying decisions are directly related, through a series of probabilities, to initial demands.

That is

$$D_C = P_C D \quad (26)$$

and from equations (17), (18), (19), and (20) it can be seen that

$$\hat{D}_S + \bar{\hat{D}}_S = D_C \quad (27)$$

and

$$\hat{P} \hat{D}_S + \bar{\hat{P}} \bar{\hat{D}}_S = D'_S = P' D_C \quad (28)$$

where P' represents the probability that a communicated demand will be satisfactorily answered within the entire political system. Finally, from equation (14)

$$D_{CS} = P'_C D'_S \quad (29)$$

Thus, combining equations (26), (28), and (29) yields

$$D_{CS} = P'_C P' P_C D \quad (30)$$

For convenience, let

$$\bar{P} = P'_C P' P_C \quad (31)$$

which leaves

$$D_{CS} = \bar{P} D \quad (32)$$

As mentioned earlier external forces are to be considered in this section. For simplicity, it is assumed that satisfying decisions is some linear function of these external forces. Therefore, the external forces,

denoted by $E[t]$, may be introduced into equation (32) to give

$$D_{CS}(t) = \bar{P} D(t) + E[t] \quad (33)$$

Applying laplace transforms to this equation yields

$$D_{CS}(s) = P D(s) + E[s] \quad (34)$$

Substituting equation (25) in equation (34) yields

$$D_{CS}(s) = \bar{P} \left[\frac{-e^{-B} D_{CS}(s)}{s - e^{-B}} \right] + E(s) \quad (35)$$

Rearranging,

$$\frac{s D_{CS}(s) - e^{-B} D_{CS}(s) + \bar{P} e^{-B} D_{CS}(s)}{s - e^{-B}} = E[s] \quad (36)$$

and

$$D_{CS}(s) = \frac{[s - e^{-B}] E[s]}{s - e^{-B} + \bar{P} e^{-B}} \quad (37)$$

$$\text{Letting } K = e^{-B} - \bar{P} e^{-B} \quad (38)$$

equation (37) may now be written as

$$D_{CS}(s) = \frac{[s - e^{-B}] E[s]}{s - K} \quad (39)$$

Thus the laplace transform of $D_{CS}(t)$ is now expressed only as a function of the laplace transform of $E[t]$. By assuming $E[t]$ to behave in a certain manner, it can be determined how this behavior affects the expected number of satisfying decisions. To illustrate, assume that the level of external forces suddenly jumps to some level \bar{E} at time $t = t_0$. That is, $E(t)$ behaves as shown in Figure 8. This might be the case where a neighboring society suddenly overthrows its government imposing certain external forces on the political system in question.

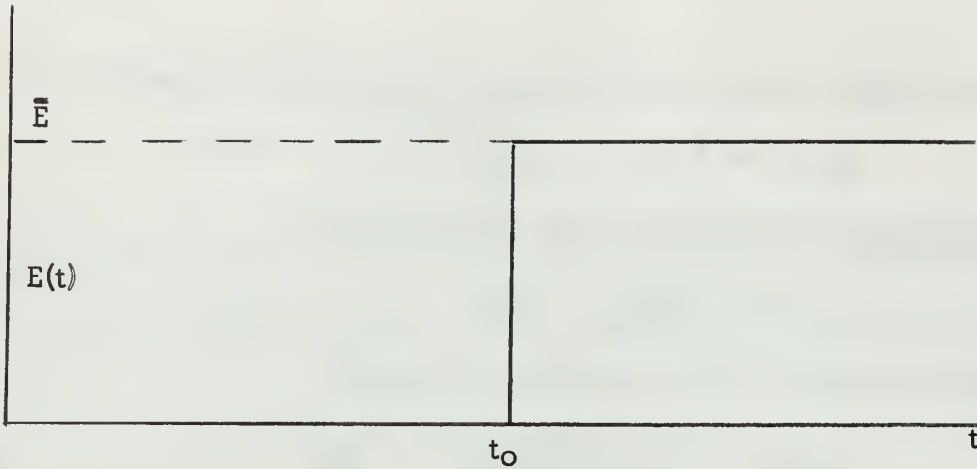


FIGURE 8

EXTERNAL FORCES - SUDDEN RISE

Now the laplace transform for this function is

$$E[s] = \frac{\bar{E}}{s} e^{-st_0} \quad (40)$$

Substituting that into equation (39) yields

$$D_{CS}(s) = \frac{[s - \rho B] \bar{E} e^{-st_0}}{s(s-K)} \quad (41)$$

Now the final value of $D_{CS}(t)$ may be found by the laplace transformation to be

$$\lim_{t \rightarrow \infty} F(t) = \lim_{s \rightarrow 0} s F(s) \quad (42)$$

Thus

$$\lim_{t \rightarrow \infty} D(t) = \lim_{s \rightarrow 0} \frac{[s - \rho B] \bar{E} e^{-st_0}}{s - K} \quad (43)$$

which yields a final value for $D_{CS}(t)$ of

$$\lim_{t \rightarrow \infty} D_{CS} t = \frac{\rho B \bar{E}}{K} \quad (44)$$

Substituting equation (38) and simplifying yields

$$\lim_{t \rightarrow \infty} D_{cs}(t) = \frac{\bar{E}}{1 - \bar{P}} \quad (45)$$

Notice that the expected number of satisfying decisions, after the crises had occurred, reaches a steady state value proportional to the level of the crises. Further, the proportionality constant, $\frac{1}{1 - \bar{P}}$, gets larger as \bar{P} increases. That is, as the communications system performs better and as the bureaucratic structure becomes more specialized the expected number of satisfying decisions increases. If $\bar{P} = 1$, the steady state value for $D_{cs}(t)$ is undefined. This is not unreasonable when we consider that for $\bar{P} = 1$, the communications and complexity systems must be absolutely perfect. In the real world, this is hardly plausible.

From equation (32) it is seen that

$$D_{cs}[s] = \bar{P} D[s] \quad (46)$$

Substituting this in equation (39) yields

$$D(s) = \frac{[s - \ell B] E[s]}{\bar{P} [s - K]} \quad (47)$$

and using the same external force function, equation (47) becomes

$$D(s) = \frac{[s - \ell B] \bar{E} e^{-st_0}}{s \bar{P} [s - K]} \quad (48)$$

Applying the laplace final value theorem, it is seen that

$$\lim_{t \rightarrow \infty} D(t) = \frac{\ell B \bar{E}}{\bar{P} K} = \frac{\bar{E}}{\bar{P} [1 - \bar{P}]} \quad (49)$$

Here it is seen that the steady state value for the number of demands generated from society is also proportional to the level of external forces. It is interesting to note that the steady state value for the number of demands reaches its minimum value when $\bar{P} \rightarrow .5$ while steady state value of the

expected number of satisfying decisions approaches its minimum value as $P \rightarrow 0$. From this it might be inferred that people tend to generate more and more demands when the probability of these demands being satisfied is low. As the probability of satisfaction starts to increase, the number of generated demands becomes less. As the probability increases beyond .5, however, people learn that their demands are being satisfied and therefore increase their demands as the probability increases from .5.

The final factor which would be effected by these external forces is that of stress. From equation (20) it is seen that

$$D(s) = \rho S(s) \quad (50)$$

Substituting equation (50) in equation (48), yields

$$S(s) = \frac{[s - \rho B] \bar{E} e^{-st_0}}{\rho \bar{P} s [s - K]} \quad (51)$$

Again applying the laplace final value theorem,

$$\lim_{t \rightarrow \infty} S(s) = \frac{\bar{E}}{\rho \bar{P} [1 - \bar{P}]} \quad (52)$$

From equation (52) it is seen that the level of stress is also directly proportional to the external forces. The stress level responds to \bar{P} similarly as demands, but is of a greater or lesser magnitude, depending upon the value of ρ .

As another example consider the situation where the external force level is continuously rising, as would be the case of increasing international tension. In this case, $E(t)$ would appear as in Figure 9, where $E(t) = At$. For simplicity assume $A = 1$. Now the laplace transform for $E(t)$ is

$$E(s) = \frac{1}{s^2} \quad (53)$$

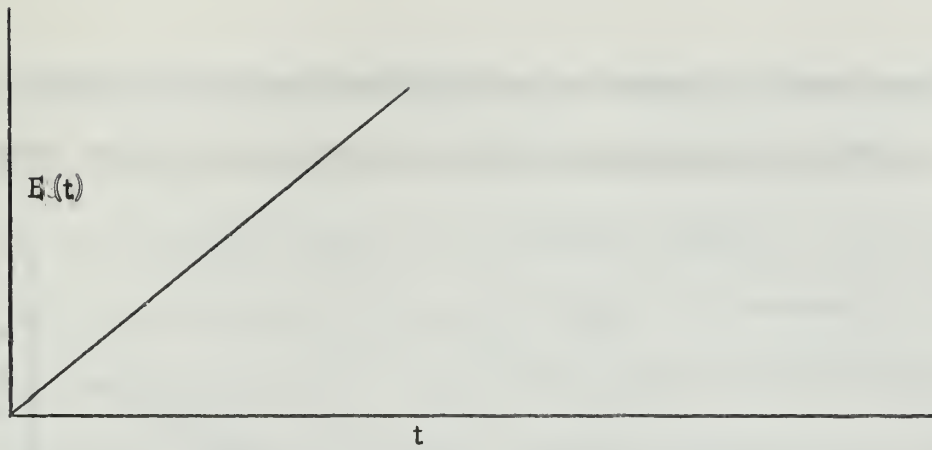


FIGURE 9

EXTERNAL FORCE - STEADY RISE

Substituting this in equation (39) yields

$$D_{CS}(s) = \frac{s - \ell B}{s^2 [s - K]} \quad (54)$$

Applying the final value theorem it is seen that

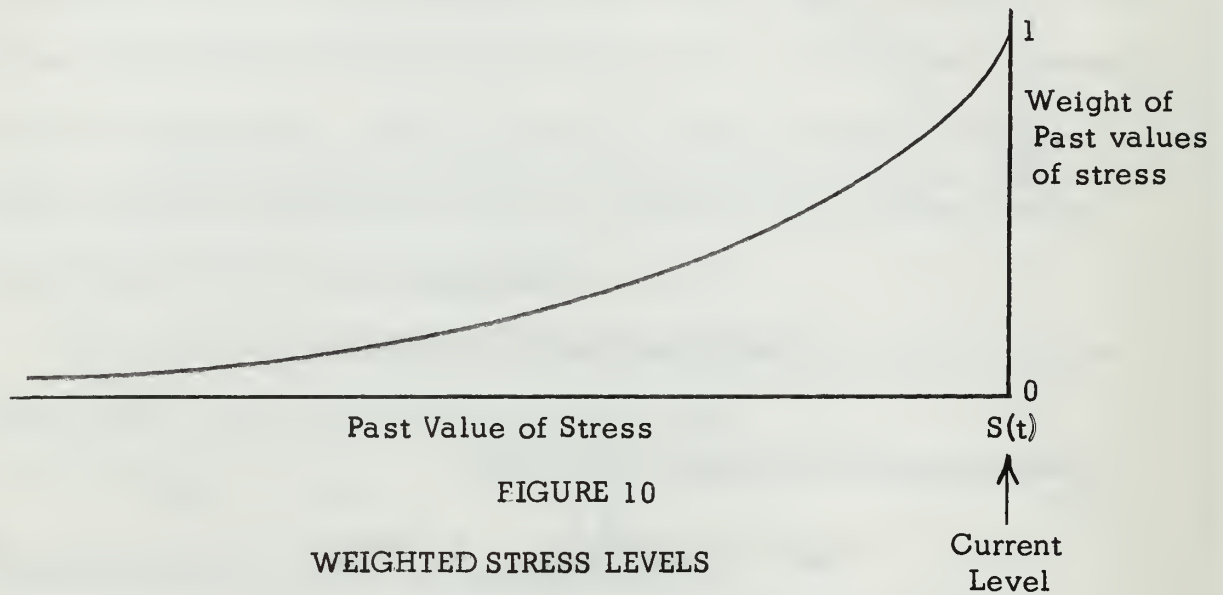
$$\lim_{t \rightarrow \infty} D_{CS}(t) \longrightarrow \infty \quad (55)$$

That is, as the external forces get extremely large, the expected number of satisfying decisions becomes undefined. From the preceeding analysis it is seen that a similar argument holds for demands and stress. From this, it may be inferred that as the external forces becomes large, the very existence of the political system and society is doubtful.

3.5 External Forces - Lag Time.

In the previous section it was assumed that the current level of demands was proportional to the current level of stress. It is now postulated that the current level of demands depends upon not only the present stress level, but also on previous stress levels. For convenience it is assumed

that the past levels of stress are weighted exponentially as shown in Figure 10. With this weighting function the society acts on the average as



if the current level of demands were proportional to the level of stress τ time units in the past.

Mathematically, this notion is expressed in terms of laplace transforms as

$$D(s) = \frac{S(s)}{\tau s + 1} \quad (56)$$

The term, $\tau s + 1$, is also known as a first order time lag.

Another way of looking at this problem is to consider the idea of a marginal demand, or the next demand generated. This marginal demand is assumed to be proportional to both the current level of stress and the current level of demands. Symbolically,

$$\frac{dD(t)}{dt} = \frac{1}{\tau} \left[\rho S(t) - D(t) \right] \quad (57)$$

where the proportionality constant, $1/\gamma$, is represented in a manner such that its meaning relative to the previous interpretation is clear. To better understand this idea consider the following example. If, for a given stress level, the current level of demands is high, the propensity to generate one more demand is quite low, while if the current level of demands is low, the propensity would be much greater. It can be shown that the laplace transform of equation (57) is identical with equation (56).

In order to express the laplace transform of demands in terms of the laplace transform of the expected number of satisfying decisions it is convenient to proceed as follows. Recall that

$$\frac{dS}{dt} = B [D(t) - D_{CS}(t)] \quad (58)$$

Equation (58) may be expressed in terms of laplace transforms as

$$S(s) = \frac{B}{s} [D(s) - D_{CS}(s)] \quad (59)$$

Substituting this expression into equation (56) and rearranging, yields

$$D(s) = \frac{-\rho B D_{CS}(s)}{[s(\gamma s + 1) - \rho B]} \quad (60)$$

Now it is also assumed that marginal demands are also dependent on the present level of satisfying decisions. From an argument similar to the one leading to equation (57), it is possible to express marginal demands in terms of the expected number of satisfying decisions as

$$\frac{dD(t)}{dt} = \frac{1}{\gamma_1} \left[D_{CS}(t) - P D(t) \right] \quad (61)$$

where γ_1 represents the time lag between decisions and demands. Rearranging equation (61) yields

$$D_{CS}(t) = P D(t) + \gamma_1 \frac{dD(t)}{dt} \quad (62)$$

Including the external forces, equation (62) may be expressed as

$$D_{CS}(t) = \bar{P} D(t) + \tau_1 \frac{dD(t)}{dt} + E(t) \quad (63)$$

Taking the Laplace transform of both sides of equation (63) yields

$$D_{CS}(s) = \bar{P} D(s) + s \tau_1 D(s) + E(s) \quad (64)$$

Rearranging

$$D_{CS}(s) = D(s) (\bar{P} + s \tau_1) + E(s) \quad (65)$$

Substituting equation (60) in equation (65) yields

$$D_{CS}(s) = \frac{-\rho_B D_{CS}(s) (P + s \tau_1)}{s (\tau s + 1) - \rho_B} + E(s) \quad (66)$$

Rearranging it is seen that

$$D_{CS}(s) = \frac{(s^2 \tau + s - \rho_B) E(s)}{s^2 \tau + s - \rho_B + \rho_B \bar{P} + \rho_B s \tau_1} \quad (67)$$

Again, assuming external forces behave as shown in Figure 8, the Laplace transform for $E(t)$ is

$$E(s) = \frac{\bar{E}}{s} e^{-st_0} \quad (68)$$

Substituting this in equation (67) yields

$$D_{CS}(s) = \frac{\bar{E} (s^2 \tau + s - \rho_B) e^{-st_0}}{s(s^2 \tau + s - \rho_B + \rho_B \bar{P} + \rho_B s \tau_1)} \quad (69)$$

Applying the Laplace final value theorem it can be shown that

$$\lim_{t \rightarrow \infty} D_{CS}(t) = \frac{-\rho_B \bar{E}}{-\rho_B + \rho_B \bar{P}} = \frac{\bar{E}}{1 - \bar{P}} \quad (70)$$

Taking the Laplace transform of equation (62) yields

$$D_{CS}(s) = \bar{P} D(s) + s \tau_1 D(s) = D(s) (\bar{P} + s \tau_1) \quad (71)$$

Substituting this in equation (69) yields

$$D(s) = \frac{(s^2 \tau + s - \rho_B) \bar{E} e^{-st_0}}{(s^2 \tau + s - \rho_B + \rho_B \bar{P} + \rho_B s \tau_1) (\bar{P} + s \tau_1)} \quad (72)$$

Applying the laplace final value theorem

$$\lim_{t \rightarrow \infty} D(t) = \frac{-\ell_B \bar{E}}{(-\ell_B + \ell_{B\bar{P}}) \bar{P}} = \frac{\bar{E}}{\bar{P}(1 - \bar{P})} \quad (73)$$

Finally, substituting equation (56) into equation (72) and rearranging yields

$$S(s) = \frac{(1 + s\tau)(s^2\tau + s - \ell_B) \bar{E} e^{-st_0}}{\ell(s^2\tau + s - \ell_B + \ell_{B\bar{P}}) \bar{P} + \ell_{Bs}\tau_1)(\bar{P} - s\tau_1)(s)} \quad (74)$$

and from the laplace final value theorem

$$\lim_{t \rightarrow \infty} S(t) = \frac{-\ell_B \bar{E}}{\ell(-\ell_B + \ell_{B\bar{P}}) \bar{P}} = \frac{\bar{E}}{\ell \bar{P}(1 - \bar{P})} \quad (75)$$

Now, assuming external forces behave as shown in Figure 9, the laplace transform of $E(t)$ is

$$E(s) = 1/s^2 \quad (76)$$

Substituting this into equation (67) and applying the laplace final value theorem it can be shown that

$$\lim_{t \rightarrow \infty} D_{CS}(t) \longrightarrow \infty \quad (77)$$

That is, the expected number of satisfying decisions is undefined in the limit. Similarly it can be shown that stress and demands behave in the same way as t is allowed to approach infinity.

From the analytical techniques employed it is seen that the steady state values for stress, number of demands and expected number of satisfying decisions is not affected by the introduction of lag time into the system. That is, in the long run the behavior of the people and of the political system is not related to any lags which may be present. However, lags are the important element in the short run analysis.

4. Summary and Conclusions.

In this thesis the methodology of systems analysis is used in order to better understand the complex interactions involved in the area of politics. Primarily, the interactions considered were those involved with demands and decisions in response to those demands. The analysis then followed on the premise that any factor which would increase the political system's ability to successfully satisfy demands would be beneficial to the political system in that a reduction in stress would follow. Finally, the effect of forces external to the political system and society were investigated.

In concluding it is felt that the methodology used in this thesis is beneficial toward understanding some of the factors which can increase or decrease the chances of a political system remaining viable under certain conditions. Although the success or failure of a political system is based primarily on its ability to successfully answer demands, other criteria came to mind during the writing of this thesis.

Perhaps one of the most important factors which should be investigated is the ability of the political system to issue demands which would successfully lead the society toward certain goals. The problem becomes much more complex here when one considers that such decisions might not be at all satisfying to the members of the society. People would accept or reject such decisions based on the amount of "trust" they had in the political system. Also the enforcement required to back such decisions would have to be considered. It is felt, however, that these seemingly complex con-

siderations can be studied analytically through techniques similar to those used in this thesis.

Another factor which should be taken into account is that of the economic situation and its relationship with the political system. For example, if the people are demanding resources which are scarce, the political system must find some way to effectively answer these demands. Inherent in this argument might be the political system's response to certain foreign aid possibilities.

Generally, systems analysis offers a method of reducing highly complicated concepts into terms which are understandable.

That such an approach offers any final answers is unknown, but it represents one of the few methods for analyzing highly complex interrelated systems in an organized manner. Further work will be needed to answer the more ultimate question.

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4. DESCRIPTIVE NOTES (Type of report and inclusive dates) Thesis			
5. AUTHOR(S) (Last name, first name, initial) DITTRICK, John H. Jr., LT, U. S. Navy			
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11. SUPPLEMENTARY NOTES		12. SPONSORING MILITARY ACTIVITY	
13. ABSTRACT Certain aspects of political functioning are investigated through the use of mathematical systems analysis techniques. Formal relationships are developed with respect to some of the elementary functions involved in politics. These relationships involve society and the political system in terms of demands, decisions and stress. Further, the concepts of communications and specialization are introduced as means of enhancing the ability of the political system to make satisfying decisions. The functioning of the system is analyzed in its steady state and a comparison is made with and without the introduction of lag time.			

14. KEY WORDS	LINK A		LINK B		LINK C	
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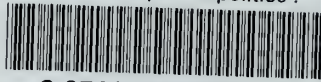
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